Nomination of

THE BURDEKIN RIVER BRIDGE

for recognition as a

ENGINEERING HERITAGE MARKER

UNDER THE HERITAGE RECOGNITION PROGRAM

By Anthony Carey
EHA (QLD Panel)

and

Ervin Smith
Department of Main Roads

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BASIC DATA:

Item Name: The Burdekin River Bridge.

The bridge spent 44 years without an official name until on the 28th of August 2001, the crossing was officially named The Burdekin River Bridge by the Burdekin MP Steve Rogers.

Other/ Former Names: Locally referred to as "The Silver Link".

Location: Spans the Burdekin River at a location approximately 17.7km from the coast. It links the North Queensland townships of Ayr and Home Hill and carries both the North Coast Rail Line and the Bruce Highway. It is 105km south of Townsville.

Suburb/ Nearest Town: Located between Ayr to its North and Home Hill to its South. The Silver Link Interpretive Center, which opened in 2007 to mark the 50th anniversary of the Bridge, is located on the main street of Home Hill.

State: Queensland

Local Govt Area: Burdekin Shire Council

Owner: Jointly owned by the Queensland Department of Main Roads and Queensland Rail.

Current Use: Double-lane highway (Bruce Highway) and a single railway line (North Coast Railway). Internal Advice sourced from Main Roads (Denise Elrick – Technical Officer, Traffic and Road Safety) quotes the following statistics for daily traffic:

On average, 7074 vehicles cross the bridge everyday.
On average, 84 road trains (including B Doubles, Double Road Trains, and Triple Road Trains) cross the bridge everyday.
On average 295 small trucks cross the bridge everyday.

Designer: The Co-Ordinator-General as the construction authority delegated the following design tasks:

Railway Department – design and construction of track and signal work
The Main Roads Commission – design and construction of substructure, earthworks and approach roads.
The Bridge Board, Bureau of Industry (subsequently transferred to the Co-Ordinator-General's Department) – design and erection of superstructure, with special mention given to:

Mr. H. G. Bramed, Senior Engineer for Design (Structures) – combined lower deck chord system.
Mr. W. Hansen – Engineer-in-Charge on site during erection.
Mr. S. Thompson – Superintendent of Steel Erection.
Mr. H. W. Fisher – Department's steel inspector.
J. E. Kindler – Deputy Chief Engineer during design of superstructure. Later appointed Chief Engineer in 1954.
Mr. J. A. Holt – Chief Engineer during design of superstructure. Later appointed Co-Ordinator-General.

Maker/ Builder: Authority was given to the Co-ordinator General of Public Works, Sir John Kemp, under the authority of the Queensland Government to carry out the work.
Construction of the substructure, control of the earthworks, and the road construction was the responsibility of the commissioner of Main Roads, Mr D. A. Crawford.
The erection of the superstructure was the responsibility of the Co-ordinator-General of Public Works under the leadership of Mr. J. A. Holt.
The Railway Department was responsible for all track and signal work.

Year Started: Construction began in April 1947.

Year Completed: The Bridge was officially opened on the 15th of June, 1957.

Physical Description: The Burdekin River Bridge is a high-level, dual purpose bridge with 10 main spans and 22 approach spans. It was built slightly upstream from the previous low-level crossing and is designed to give 10ft of clearance above the highest known flood level of the area. Each main span is 250ft in length (76m) and utilizes a 'through' truss bridge configuration of two Pratt trusses connected across the top and bottom. Three 60ft composite plate girder, and eight 45ft steel joist viaduct spans are located at each bank bringing the total length of the structure to 3,619.4ft (1103m).

The superstructure has a total width of 42ft between the center of trusses. The total width includes a 22ft roadway between kerbs and enough clearance to carry a standard 4ft 8in gauge railway track. A 4ft wide footway is provided for pedestrians with access stairs at the main bank piers of the bridge. The through truss is approximately 13m tall with the maximum allowable vehicle height being 4.62m.

The Burdekin River Bridge is said to be the only bridge in Australia that has been built without a firm foothold. The bridge rests on nine reinforced concrete caissons and 2 abutments. Each caisson was sunk to a depth of roughly 100ft below the bed-level of the river (50ft below the lowest calculated scour level), with one caisson on each bank being sunk to 120ft. Each of these caissons measures 56ft in length and 25ft in width, with semi-circular ends and a wall thickness of 2ft, 6in. Both of the approaches are supported on reinforced concrete piers that are founded on concrete piles driven into the banks of the river.

Construction of the superstructure involved the use of 7000 tonnes of high-strength fabricated steel. Additional to this was the use of over 300,000 high-strength bolts for field connections, which is recognised as Australia's first application of these fasteners. The caissons contained 2400cu.yd of concrete each, and a further 785cu.yd of concrete is contained in the hollow reinforced concrete piers above these caissons.

Physical Condition: The Bridge is generally in good condition. The structural steel work has been subjected to constant maintenance and repair since 1991. This rehabilitation work is expected to continue until 2012. It is proposed that the bridge will then be completely repainted. Initially maintenance of the superstructure was carried out by QR however this was handed over in 1990 to the Department of Main Roads. The integrity of the bridge is hoped to be preserved to extend its working life for a further 100years under the current Main Roads contract.

Modifications/ Dates: A permanent mobile, maintenance gantry was placed on top of the bridge in the early 1990s but there have not been any modifications to the structure.

Historical Notes:

Seventy years prior to the bridge's conception, North Queensland was in a quandary over the direction in which trade routes should be established between the communities. In 1883, surveys were ordered to investigate a route between Bowen and Ayr. The Burdekin River proved to be an engineering difficulty and as such instructions were received to survey Bowen to the Haughton Gap Line, the intention being to open trade between Charter's Towers out west and the Bowen area.

Townsville and Ayr, however, had interests in creating a coastal line direct to Townsville. Bowen did get a railway, yet the dispute had the consequence of halting construction at Bobawaba, about 25km south of Home Hill. For a decade, the local authorities were indecisive, and a triangular section of rail track was constructed to allow trains to turn around short of the Burdekin River. Following the success of the Ayr Tramline however, the North Coast Railway Act of 1910 was passed and the decision was made to cross the river linking Bowen with its northern neighbours. At the time Townsville's port was thought to be sub-standard to Bowen's. It is interesting to note that had the decision been made to construct the western rail between Bowen and Charter's Towers, Bowen could very well have grown to be as big or bigger than Townsville. Today Townsville is the largest city in tropical Australia.

Originally a high-level bridge was planned to span the river, and cast iron cylinders were ordered from Maryborough. Once it was realized that there was no rock on which to found, only sand, the idea was abandoned and the cylinders were used elsewhere, including Reid's Creek Bridge on the Gayndah-Monto line. Eventually in 1913 a low level bridge, officially named the Inkerman Bridge, was constructed and carried both road and rail over the temperamental river.

For many years following, the line was repeatedly interrupted by flooding. It became commonplace for the railway line to be impassable on an average of 17 days a year, as well as the road an average of 40 days a year. Growing frustration with the unrelenting flooding eventually reached a peak in 1939 and the local authorities began assessing the viability of constructing a high-level bridge over the Burdekin River. This investigation however was halted with the eruption of World War II.

With the vulnerability of the North during the war still fresh in the minds of the Government the investigation resumed in 1945. This was spurred on by the occurrence of flooding in1945 which claimed the lives to two train passengers when a wall of water washed the train from the tracks and destroyed several spans of the low level bridge. In 1946, construction of the bridge was authorized with the establishment of The Burdekin Bridge Board constituting the Co-ordinator General, Main Roads and Railway Departments jointly venturing in the design and construction of the bridge. During this time, two engineers were sent to India to investigate designs for the bridges with deep foundations in sand with particular attention paid to the problem of scouring of the river-bed.

Construction began in 1947 with the substructure. By 1950, six of the nine large caissons were completed and plugged. More would have been built had it not been for the flooding in 1949. The window of opportunity to carry out the work in the river-bed was usually only open from May to December during which time the river was confined to a narrow channel on the north bank. Further delays were enforced by flooding in early 1951, yet by 1953, the substructure

for the southern approach viaduct, the main south bank pier, nine river piers, and the main north bank pier were built with the northern bank viaduct nearing completion.

7000 tons of high-strength steel was required to be sourced for the superstructure. Of this amount, 800tons was fabricated on site to save transport costs, and also to provide a means of gainful employment for the boilermakers in the wet season. The remainder was sourced from Brisbane with contracts being awarded to Drysdale and Ridgway Pty Ltd for the approach span bearings and girders (450ton in Jul 1947), and Evans Deakin & Co. Ltd. for the bearings of the main span (120ton in Jun 1949) as well as for the trusses, bracing and deck (5200ton).

In addition to this 300,000 high tensile-strength bolts were used for field connections in place of the traditional method of riveting. This was largely due to the difficulty in attracting and holding at site skilled labour in the metal trades that were required for field riveting. These bolts were a new technology and at the time, in 1949, tests were being conducted in the U.S.A. by the American Railway Engineering Association (A.R.E.A.) to assess the widespread application of these fasteners in place of rivets. The test concluded the superiority of these fasteners and, in the same year, A.R.E.A. was approached by the Burdekin design team for more information.

Tenders were called out in 1951 for the production of the bolts with responses from Australian, British and German manufacturers. Eventually in 1953, contracts were awarded to The Sydney Steel Company Pty. Ltd. for the bolts, and the West Footscray Engineering Works Pty. Ltd. of Melbourne for the washers. The first bolts were delivered in June 1954 and were complete in August 1956. Despite delays and a number of rejections of bolt quality, the Australian manufactures managed success in the development of this new technology with little assistance from prior similar experience. The Burdekin River Bridge is recognised as being the first Australian application of these type of fasteners and, at the time, was considered to be the largest bridge with high tensile-strength bolts as fasteners in the world.

At any one time, it was recorded that 253 men may have been engaged in the job throughout all of the trades. Despite this, problems arose during construction due to the lack of material, the lack of cement and steel, and the slow delivery time of steel imported from overseas. With steel deliveries slow following World War II and throughout the course of the Korean War (1950-53), coupled with debilitating flood events, the construction of the bridge spanned a decade at the cost of $6million. The last delivery of steel was made in 1956 and the bridge was officially opened on the 15th of June 1957, just before the start of the 1957 wet season.

Today remnants of the old low-level bridge are still visible during low tide downstream from the new Burdekin River Bridge; as to are the foundations of the triangular section of railway at Bobawaba. The section of track remained after the construction of the first low-level crossing to allow trains to turn around in the event that the crossing was flooded. Once the high-level Burdekin River Bridge was completed in 1957, this section of track was removed.

Listings: No listings have been found on either the Queensland Heritage Register, or the Australian Heritage Database.

ASSESSMENT OF SIGNIFICANCE:

Historic Phase:

The conception and successful realization of this structure was driven by the strong feelings held by the surrounding communities at the time to create the necessary trade corridors that would help this corner of North Queensland to progress. The structure has been in existence as a proposal and as a reality since 1940, yet the need to create an interface between the Townsville and Bowen regions by negotiating the Burdekin River is one which has been confronted since the late 1800s. The bridge is in current use and its life expectancy is considerable. Only duplication proposals rather than replacement are in existence, highlighting the continuing and developing importance of the link between these regions of Queensland.

Historic Association:

Many engineers who later rose to senior positions in the Department of Main Roads gained experience on the construction of this structure. It was almost used as a training ground as at the time of construction it was the major engineering project in Queensland.

Creative or Technical Achievement:

The design and construction of the Burdekin River Bridge required high levels of technical innovation and achievement due to the challenging nature of the site, and to a similar extent, the climate of the construction industry at that particular time in history.

Creating a crossing over the Burdekin River meant crossing the fourth largest river in Australia in terms of volume of flow. The extreme variability of precipitation over its basin means that the river experiences extremely erratic discharge events. This has been known to reach that of the Yangtze River (after two severe cyclones in 1958) with a 100year flood event approximating discharges of 1,500,000cusecs; of this it is estimated a little over a million cusecs would flow through the main channel which is approximately half a mile wide. The opposite end of the scale has seen the river experiencing no flow whatsoever for periods up to seven months (as in 1923). Building a structure to cross this temperamental body of water was therefore, at the time, an engineering feat of the highest magnitude.

Foundations:

The foundation of the bridge was a substantial engineering challenge. Beneath the Burdekin is a bed of sand 150ft thick which meant that there was no substantial bearing material for the bridge to be founded on. Instead caissons were sunk to a depth of 100ft below the river bed, and 50ft below the lowest calculated scour level. Each caisson had a 12.5ton steel cutting edge that was required to cut through the sand as the caisson was sunk to the required depth. The sinking was achieved by first launching the cutting edge from a platform 15ft high into the river bed to allow the edge to sink evenly into the sand. This was followed by a combination of concreting, pumping, and open dredging using a 2cu.yd double line clamshell grab operated by an electric crane. The main northern bank caisson also required 800ton of kentledge, in the form of boxes of sand, during its final stages of construction to reach its required depth.

The caissons were divided into 5 compartments. Once the required depth was reached, these compartments were plugged, 95ft under water, by a 7ft thick layer of concrete. The silt was then pumped out with the aid of a diver, the plug was inspected by hand, and an additional 7ft plug was cast on top before the compartments were refilled with water. Considerable diving work was required with dives of 100ft becoming normal everyday routines. For this reason high standards of efficiency and safety had to be met. These divers followed the strict provisions of the S.A.A. compressed air code and reference to the Royal Navy diving manual. In addition to this, they were trained by an ex-Royal Australian Navy diver. First hand accounts from divers revealed the testing nature of their work in an online story produced by the ABC named “Memories from the Burdekin Bridge - Diving for the bridge: George Odgers' story”:

“All that work was done by feel. After you left the surface, after you disappeared, it was all black.”

“It’s pretty hard work, sometimes you’d sweat underwater,” George says. “You’d come up and be glad to see daylight.”

This type of foundation was the first of its kind to be attempted in Australia and today remains an incredible engineering feat for being constructed without a firm foothold.

Superstructure

High levels of innovation were incorporated throughout the design of the superstructure. The nature of the site often dictated the method in which construction would take place, the loads from which often dictated the size of members in the design. It was known that rain events large enough to interrupt work could occur at anytime of year. Orthodox false-work could not be used as it would be washed away in the flood waters. For this reason, the main spans were erected by free-cantilever between successive piers which dictated the member sections to be used in the trusses, the bearing arrangement details, and the choice of material. The Pratt truss triangulation was adopted as it reduced the secondary stresses during construction when compared with the alternative of the Warren Truss. High tensile steel was selected in order to reduce the weight, and hence the required size, of the main member sections to achieve the required cantilevers. Reductions of 1100tons were realized in comparison to the use of conventional steel. The selection of member sizes placed large emphasis on weight reduction. The main chord members of the trusses were designed as fully plated box sections. These were inspired by the Birchenough Bridge in former Rhodesia. Full-sized models of joint assemblies were built in timber to check assembly problems.

Kindler claims that an original solution to reconciling the dissimilar displacements that occur between the linearly unrestrained deck system and the main system supporting deck, always most prevalent in ‘through’ bridges, was implemented in this design. To reduce the number of field connections required for expansion joints in the stringers, they were detailed as being continuous over a length of 250ft by means of continuing flanges through the girder webs. Chief Engineer J. A. Holt directed from an early stage that an attempt be made to reduce the stresses that are developed as a result of this continuity. Anchor trusses at the end of each span were introduced such that when under load, the change in length experienced by the lower chords of the trusses must strain all four stringers. What resulted from this was a deck of unusual rigidity. Some economy was also realized with reductions in the total weight of steel and the elimination of numerous field-installed fasteners. The stress history of the whole deck under analysis suggested that each member would be within its elastic range under all design action cases meaning that structural maintenance of the deck steel work since its erection has been greatly eliminated.

The design of the moving bearers for the superstructure was based on those used for the Fitzroy River in Rockhampton, however higher levels of Brinell hardness were required. These bearers were successfully designed despite encountering several difficulties. Their arrangement required them to accommodate all changes in slope of the main trusses due to the design loads. Out-of-plane changes in slope of the cross-girders however were not accommodated for and hence fixity of the bearers in this plane was present. The effects of this restraint were investigated and in no instance did instability or stressing beyond elastic limits occur. As these bearers were designed as ‘moving’, the effect of friction needed to be analysed. At the time, no technical literature was available to help determine a co-efficient of friction. Therefore full scale testing was carried out in the University of Queensland Engineering Laboratory. The design eventually adopted for this bridge was later adopted for the bearings of the Indooroopilly Railway Bridge which was a testament to ingenuity of the design.

High-Strength Bolts

The decision to use high-strength bolts was made as a consequence of the failure to secure the required labour for the specialist metal trades involved in extensive riveting. The A.R.E.A. in 1949 conducted tests on the new technology and concluded their superiority in performance when compared with rivets. Load transfer was assumed to be achieved through the inter-plate friction induced as a result of the clamping forces associated with the applied torque in the bolts. This proved to be a better method of transfer rather

than relying on the direct bearing onto the rivets. Due to the lack of guidance at the time however, the proportion of high-tensile fasteners to be used for a connection was calculated as per the provisions for rivets. In later codes of practice, provisions for the increased permissible bearing pressure of fasteners would have been recognized. The tensile capacity of the connection was also increased by the used of these fasteners as it was deduced that a tension force could only be applied to a bolt by overcoming the clamping force induced in the plates.

Other advantages of using these bolts were also recognized. A 50% reduction in noise between impact wrenching bolts and the driving of a rivet-gun for the hot-driven rivets was achieved. The bolts also allowed simpler handling of joints, especially for the main chord splices. From a construction point of view, the bolts were useful for rapid assembly and also negated the need to position a heavy rivet furnace on an incomplete span – an advantage also noted by the construction crew as the heat generated from the equipment would have been uncomfortable in the tropical climate. While the unit cost delivered to site of bolts were more expensive than the rivets, the installed cost of the bolt proved to be less with all the overheads included. Regardless of this, at no stage during construction could riveters have been obtained.

The Burdekin River Bridge is recognized as being the first Australian application of this type of fastener, the largest bridge in the world at the time to use these fasteners, and was therefore at the time a major technical achievement.

Maintenance

The peculiar requirements of the Burdekin River Bridge required various innovations and the use of initiative by the project manager and design advisor to the project. The maintenance plan for the structure was “Highly Commended” by the Institution of Engineers Australia in 1991 for their innovative work. An example of this is emphasized with considering that the superficial area of steel for one 250ft span is estimated at 71,700sq.ft, each square foot of which was coated with red-lead paint. Maintenance crews repair and replace corroded members, bolts and remove the original, flaking lead based paint by means of a needle gun with a vacuum shrouds. This innovative devise captures the loose flakes to allow them to be disposed on in an approved waste site.

Research Potential:

The myriad of innovations inherent throughout the design, fabrication, construction, and maintenance of the Burdekin River Bridge would have over the decades set a precedent for structures of a similar nature. In particular the performance of the high-tensile strength fasteners, and the sunken caissons of the substructure, would be worthy of research to assess their longevity. The bridge may also be of interest in the future as a site on which to research the performance of the paint. There have been suggestions that in the future the bridge may not be painted but coated with a polymer.

Social:

This unique bridge represents a significant achievement in the development of infrastructure of Queensland. At the time of its construction it was the major engineering project in the State. It is a significant landmark of the district and has engendered considerable association with the local communities. The name given to the bridge by the locals, the “Silver link” has been incorporated in the names of numerous businesses in the towns of Ayr and Home Hill which exemplifies the immense sense of pride amongst the communities. A Silver Link Interpretive Center is located on the main street of Home Hill and was opened in 2007 by the Premier to mark the Bridge’s 50th anniversary.

Rarity/Representativeness:

It may reasonably be suggested that this bridge is one of a kind in Australia. It represents the first bridge in Australia to implement high-tensile strength fasteners for field connections throughout the superstructure. It is also a rare bridge in so much as its substructure is not founded on a firm foothold, but rather is

embedded in sand. From a social perspective, the bridge is representative of the impact infrastructure has to the economic development of a region by creating interfaces between communities.

Integrity/ Intactness:

The current Main Roads contract for the maintenance work of the structure stipulates that maintenance shall preserve the integrity of the bridge and therefore extend its working life for a further 100years. Its current condition is sound, highlighted by the fact that only duplication proposals, and not replacement proposals, are currently in existence.

STATEMENT OF SIGNIFICANCE:

The Burdekin River Bridge, also known as the "Silver Link", is a unique engineering feat in the nation and permits the crossing of the Burdekin River which was formerly a serious barrier to the development of North Queensland. Construction of the bridge began in April 1947, was completed in June 1957, and was the major engineering project in the State at the time. High levels of technical innovation were achieved throughout the design and construction of this project as a consequence of the geographical characteristics of the site and the climate of the construction industry following World War II and throughout the Korean War. The bridge is unique in Australia as the entire structure is without a firm foothold, begin founded on caissons that were sunk 100ft in the sand of the river-bed. 300,000 high-tensile strength fasteners were used for the connections throughout the structure which represented the first application of these now proliferated fasteners in Australia. Further technical innovations were achieved throughout the design of the superstructure and also throughout the continuing maintenance plan engineered by Main Roads, in particular the removal and disposal of the original lead based paint. The completion of Bridge represented a turning-point in the economic development of the region and continues to be held in high-esteem as a landmark by both the local community and wider region of North Queensland. Acknowledgement of the Co-ordinator General of Public Works Department, The Main Roads Commission, and the Railway Department should be made for their ingenuity throughout the challenging design and construction of this project.

Assessed Significance: Engineering Heritage Marker

Images: Refer to Appendix A.

References:

1. **Kindler, J E et. al., (1957)** ***High Strength Bolt Field Connections at Burdekin Bridge*** The Journal of the Institution of Engineers Australia, Vol 29.

2. **Kindler, JE, (1958)** ***Burdekin Bridge Superstructure*** The Journal of the Institution of Engineers Australia, Vol 30.

3. **Fletcher, HB, (1952)** ***Australian Bridge Built on Sand*** Civil Engineer's Review, Vol 6.

4. ***Substructure of Burdekin High Level Bridge Completed*** **(1953)** Commonwealth Engineer, Vol 40.

5. http://www.history.qr.com.au/history/news/archive/press/burdekin_50th.asp

6. http://www.homehillchamber.com/centenary/Bobawaba.html

7. http://www.burdekinonline.com.au/community/events/archived/2007/burdekinbridge/

8. http://www.abc.net.au/local/stories/2008/11/20/2424837.htm

APPENDICES

Appendix A: Locality Plan
Appendix B: Images
Appendix C: Length Comparison
Appendix D: Nomination Form
Appendix E: Approval of Plaquing by Owner
Appendix F: Referenced Journals

Appendix A – Locality Plan

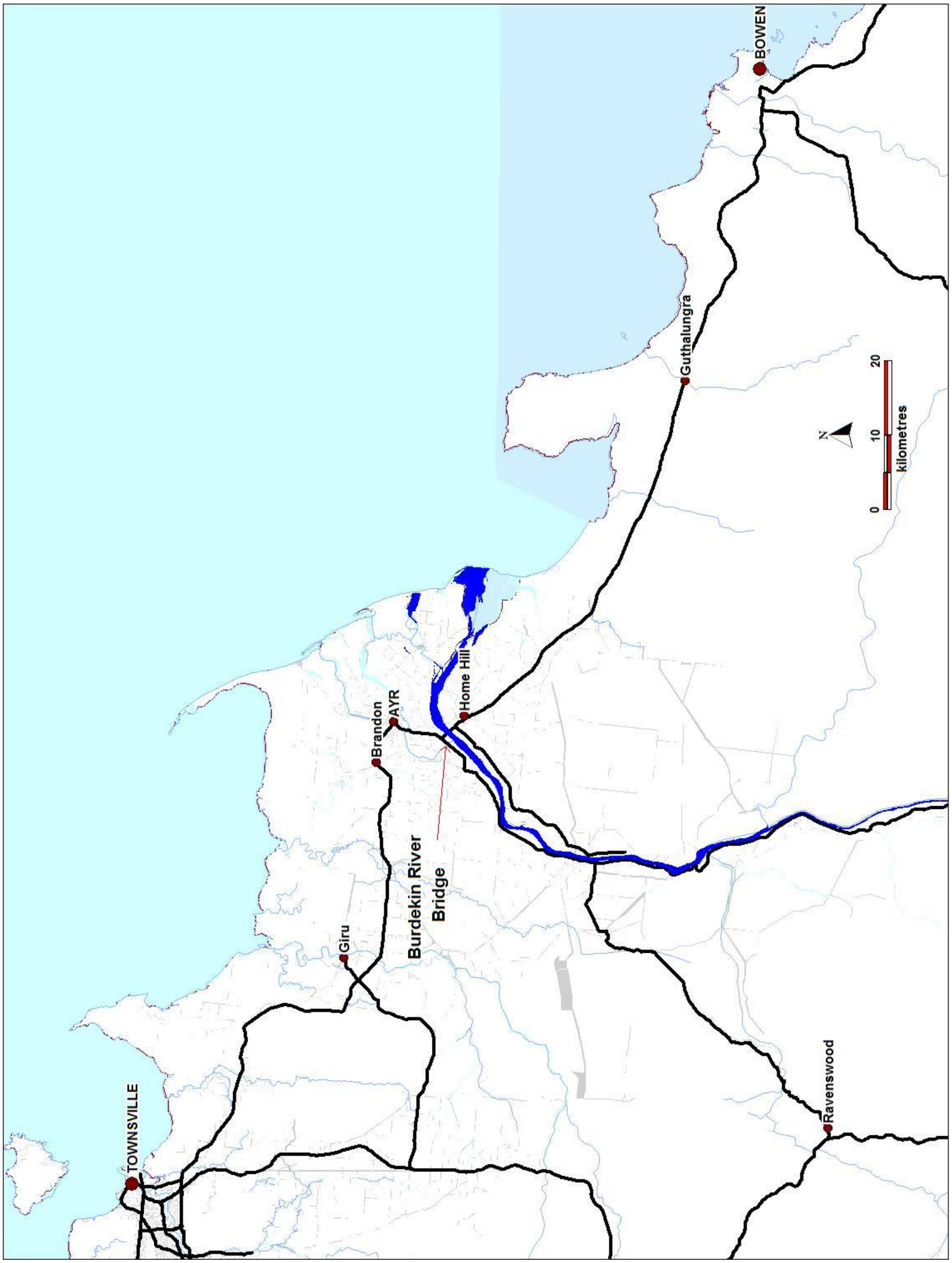


Fig 1. Locality Plan

Fig 2. Satellite Image (Courtesty of Googlemaps.com)

Appendix B – Images

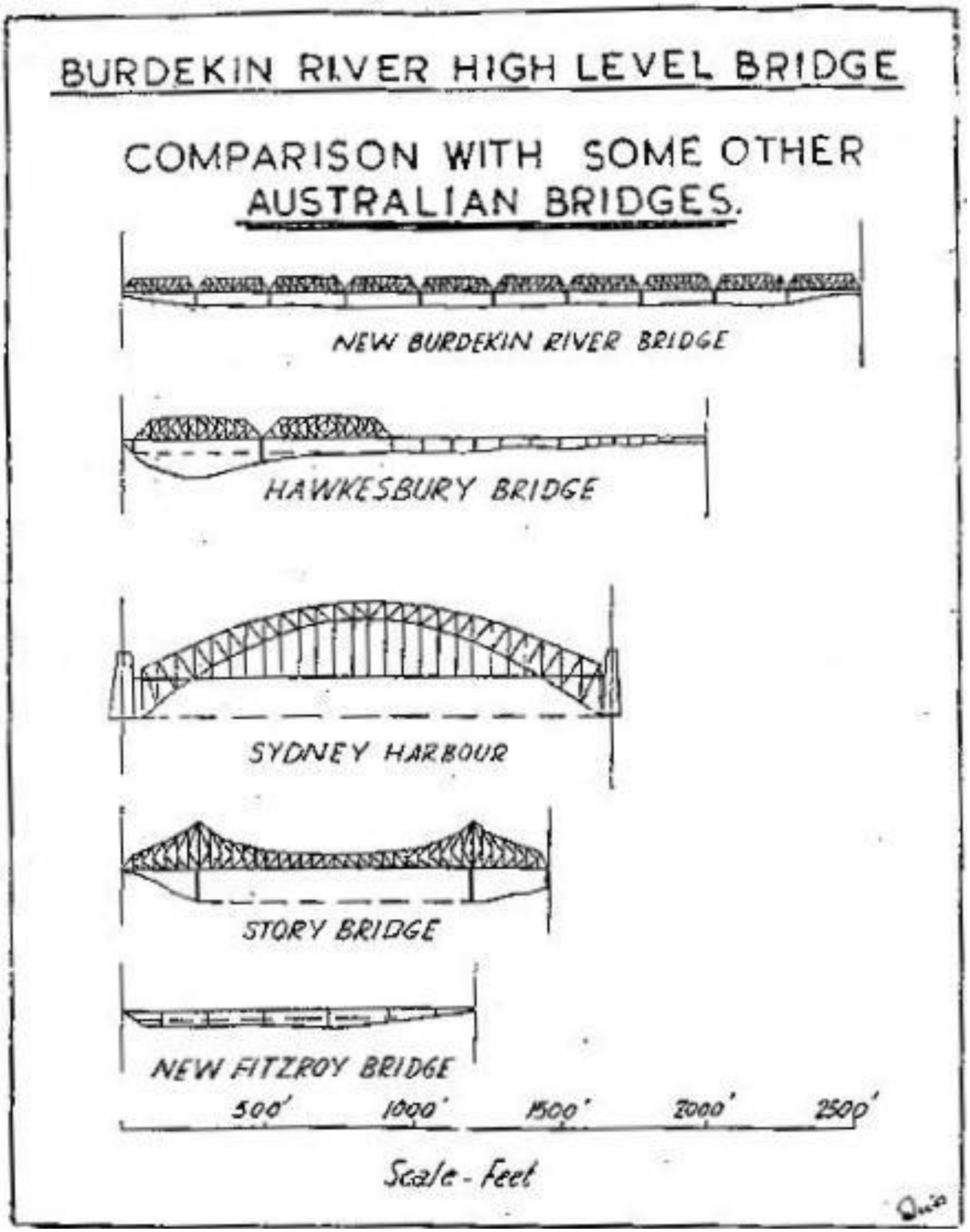
Fig 3. **Flood debris entangled on the low-level railway bridge over the Burdekin River, 1940. (Courtesy of John Oxley Library, State Library of Queensland)**

Fig 4. **Construction of a bridge over the Burdekin River, ca. 1954. (Courtesy of John Oxley Library, State Library of Queensland)**

Fig 5. **Official opening of the Burdekin Bridge, Queensland, 1957 (Courtesy of John Oxley Library, State Library of Queensland).**

Fig 6. **Burdekin Bridge in the Ayr district, Queensland, 1962. (Courtesy of John Oxley Library, State Library of Queensland)**

Appendix C – Length Comparison



Appendix D – Nomination Form

Appendix E – Approval of Plaquing by Owner

Appendix F – Referenced Journals